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SOME SPECIES OF *ODONTIA*

By CLAIR A. BROWN

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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(WITH NINETEEN FIGURES)

Introduction

The Hydnaceae, as recognized by most students of the group, is a family of the Hymenomycetes containing a heterogenous group of pileate, sessile, reflexed, and resupinate plants, characterized by the possession of teeth or spines, granules, and warty protuberances which usually point downward. These last are covered by a hymenium which usually does not extend over their apices.

Considerable intergradation occurs within the family. As a result much confusion in classification has arisen because of the difference in emphasis placed on the various diagnostic characters by different students or even by the same investigator in the course of his studies.

In 1929 the late Professor C. H. KAUFFMAN suggested the desirability of a cultural study of this group. The classification of the species collected for this study necessitated a review of the whole taxonomic situation and a comparative study of the morphology of the species. A start has been made in the study of the biology of the resupinate species of the Hydnaceae. Eleven species have been grown and their development compared on synthetic media. It is hoped that the information thus obtained will help to throw light on the relationships in the group and lead to a more usable and stable classification.

Although much attention has been devoted to the taxonomy of the Hydnaceae, comparatively slight attention has been given to a study of them in pure culture. Difficulty has been experienced in germinating the basidiospores of species in the Hydnaceae. When germination was secured, the cultures usually remained sterile or produced structures which were described as bulbils, oidia, or chlamydospores. In only a few instances were basidiospores obtained.

BREFELD (6) was the first to study species of this family in culture.

He reported difficulty in securing germination of basidiospores in the genera *Sistotrema*, *Hericium*, *Hydnum*, *Mucronella*, *Odontia*, and in the species *Grandinia granulosa* Fr. He succeeded in germinating the spores of *Kneiffia setigera* Fr., *Grandinia crustosa* (Pers.) Fr., and *G. mucida* Fr. His cultures of these all remained sterile. The basidiospores of *Phlebia merismoides* Fr., *Ph. radiata* Fr., *Ph. contorta* Fr., and *Ph. vaga* Fr. were easy to germinate and oidia were produced in eight days. The spores of *Radulum orbiculare* Fr., *R. pendulum* Fr., *R. fagineum* (Pers.) Fr., *R. molare* Fr., and *R. lateum* Fr. germinated easily. The side branches of the mycelium became constricted into beadlike chains which he did not consider typical conidia. Only *R. pendulum*, now believed to be a tuberculate form of *Corticium subcostatum* Karst., produced basidiospores in his cultures.

FALCK (17) reported fruiting of *Phlebia merismoides* in cultures, not only from basidiospores but also from a single oidium.

LYMAN (30) studied a great number of Hymenomycetes, especially species in the Thelephoraceae. He apparently also studied many of the Hydnaceae but unfortunately was unable to give much information concerning this group because he lost his data. He reported, however, that chlamydospores were obtained for this family. HOTSON (23) studied the production of bulbils and similar propagative bodies in the Hymenomycetes. He found bulbils, oidia, and basidia in cultures of *Grandinia crustosa* (Pers.) Fr., now *Odontia crustosa* (Pers.) Quél.

DESEYNES (15) and PATOUILLARD (36) observed macro- and micro-conidia in collections of *Hydnum erinaceus* Bull. and *H. coralloides* (Scop.) Fr. They mentioned the resemblance of micro-conidia to basidiospores, which, as will be shown later, they probably were.

BROOKS (7) cultured *Hydnum coralloides* on ash and secured the formation of small but typical fructifications in about four months' time. Further cultures produced abnormal fruit bodies with rudimentary spines. He secured this fruiting from spores which were collected on a sheet of clean glass and transferred to tubes containing the wood.

Methods of study

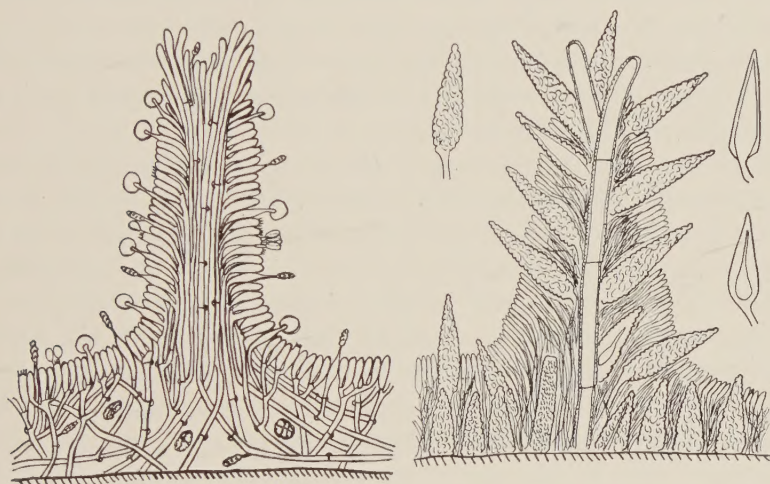
BURT (8-11) suggested a standard method of procedure for the study of specimens of the Thelephoraceae. Briefly this consists in

moistening a bit of the hymenium with alcohol, wetting it with water in order to section the material easily, then transferring the sections to 7 per cent potassium hydroxide solution to expand the tissue to nearly natural size. In some instances lactic acid was used because potassium hydroxide darkened the sections. Permanent slides were made by staining the sections with water soluble eosin, then mounting them in dilute glycerin and, when ready, cementing the coverglasses to the slides. This is essentially the procedure followed by OVERHOLTS (35). He acidified the eosin stained sections with acetic acid so that the color would not fade so readily. BOURDOT and GALZIN (5) and DONK (16) used potassium carbonate solutions colored with eosin, and chloral hydrate with iodine in their investigations of the Hymenomycetes.

In recent years several European investigators have studied the effects of various reagents on fungi, with the result that the reactions have been utilized by some as important diagnostic characters. BOURDOT and GALZIN (5) found that the use of potassium carbonate with eosin stained the protoplasts of certain types of mycelia more readily than others and used this as a supplementary character in delimiting species. Gloeocystidia are also more easily detected by the use of potassium carbonate with eosin or chloral hydrate with iodine. KÜHNER (27) has even gone so far as to use such reactions as a means of distinguishing genera. He maintains that the morphological characters alone are insufficient to separate the genera *Lentinellus* Fayod and *Lentinus* Fr., and has emended the former by recognizing the amyloid spore as the principal diagnostic character. In the Hydnaceae, the genus *Dryodon* (*Hericium*) is also characterized in part by the amyloid spore character. A striking reaction is noted by BOURDOT and GALZIN (5) in *Odontia* (*Acia*) *uda* (Fr.) Bres., which turns purple when exposed to the fumes of ammonia. They consider this a reliable means for separating this species from *O. (Acia) fusco-atra* (Fr.) Bres.

Different workers have used reagents of various kinds and strengths. The present studies show the necessity for giving the strengths of reagents used. For instance, a careful examination of sections from fresh specimens of *Odontia arguta* (L.) Quél. shows small capitate structures, herein called "capitate cystidia," which at

first may easily be mistaken for air bubbles or drops of oil in sections which have not been fully expanded or which contain air (fig. 1). Once this structure is recognized, it is easily distinguished. However, Amann's mounting medium, chloral hydrate with iodine, 95 per cent alcohol, and 0.5 per cent potassium hydroxide all rapidly dissolve the globose cap from the capitate cystidium, leaving a small, cylindrical, hyphal stalk. Although 5 per cent potassium carbonate also dissolves the cap, it acts more slowly.



FIGS. 1, 2.—Fig. 1 (left), diagrammatic sketch showing structures of spine, axillary hyphae, and capitate and oxalate incrustated cystidia. Fig. 2 (right), same showing structure of spine, incrustated axillary hyphae, imbedded and projecting cystidia. Sketch at right of spine shows cystidia after incrustations were dissolved.

Inasmuch as several of the common reagents will alter certain of the diagnostic characters, it is imperative that at least a preliminary examination of the material be made in distilled water and that the reagents be then added by drawing them under the coverglass with a piece of filter paper while the mount is under observation.

Studies of dried specimens, following the procedure outlined by BURT (8-11) or OVERHOLTS (35), may sometimes fail to reveal the presence of diagnostic characters, as 7 per cent potassium hydroxide and 95 per cent alcohol have been found too strong, destroying or

obscuring certain types of structures found in Basidiomycetes. This may account for some of the discrepancies for the same species between BURT's descriptions and those of some European workers, especially with reference to the presence or absence of incrustations on the hyphae and cystidia.

The following technique has been employed in studying specimens. Sections were mounted in distilled water for an examination for the presence of cystidia, cystidium-like organs, and incrustations. They were then treated either with 0.5 per cent potassium hydroxide or with 5 per cent potassium carbonate colored with eosin to expand and stain the spores and tissues. In the case of material which did not section readily, a small piece was soaked in water for half an hour or longer, until it sectioned easily.

Chloral hydrate with iodine, as used by STEVENS (39), was found to be a satisfactory reagent to follow distilled water when a detailed study of the section was wanted, inasmuch as it expands the tissues better than either potassium hydroxide or potassium carbonate. However, it has some solvent action. The iodine in this solution gives a yellow-brown color to the hyphae and a darker brown color to the gloecystidia. Amyloid spores of course turn blue. Sometimes the definition of an object expanded with this reagent is unsatisfactory, and in those cases the 5 per cent potassium carbonate with 0.01 per cent eosin was used. This dye stains the hyphae so that a sharp definition can be secured. The use of Amann's mounting medium or 5 per cent potassium carbonate with various dyes such as cotton blue or eosin has been helpful in distinguishing individual hyphae. As yet no one reagent has been found which is entirely satisfactory for the study of all specimens.

A solution of 10 per cent hydrochloric acid was used to remove the calcium oxalate, and with this obstructing material dissolved the structure of the specimens can be more readily ascertained.

It is difficult to make tissue cultures of the resupinate Hydnaeae, except in the case of a few species which have rhizomorphs, because the subiculum and teeth are thin. Only one tissue culture was secured. *Odontia fragilissima* (B. & C.) Brown was cultured from a rhizomorph after the usual procedure of surface sterilization in mercuric chloride followed by several changes in distilled water.

Specimens were collected in the field and wrapped in waxed paper. A spore fall was obtained by placing a specimen over sterile petri dishes or capsules. When the deposit of spores was visible (after 2–12 hours) sterile distilled water was added. The proper dilution was determined by making a fine spray on a glass slide and examining individual drops to see that the number of spores did not exceed two or three per drop. The spore suspension was sprayed on previously poured agar plates as described by KAUFFMAN (24). After germination, which takes 12–72 hours at a room temperature of approximately 20° C., germinated single spores were isolated by cutting out small blocks of agar 1 mm. square under the low power of the microscope. The spore was transferred to a sterile agar plate or to a slanted test-tube. Difficulty similar to that reported by BREFELD (6) was experienced in securing the germination of spores. Spores from field material germinated in only 17 instances out of 155 attempts. Germination from basidiospores produced in culture was much more certain.

Experiments were conducted using a maltose agar,¹ LEONIAN's agar (28), KOTILA's agar (26), a 6 per cent oatmeal agar, and a 2 per cent malt extract agar. KOTILA's agar was found to be the most satisfactory for vegetative growth and fruiting, inasmuch as basidiospores formed on this substratum 5–10 days sooner than on the others. Therefore this was used as the standard medium on which these fungi were grown. KOTILA's agar did not always solidify after the usual sterilization at 15 pounds' pressure for 15 minutes in the autoclave, and this difficulty was overcome by increasing the quantity of the agar from 20 to 30 gm. per liter of water or by sterilizing the agar at 10 pounds for 20 minutes.

The various species were also grown on filter paper pads saturated with the different nutrient solutions used for these agars. Filter paper was cut and folded into U-shaped pads and placed in an inverted position in small glass capsules, then dry-air sterilized.

Some of the species studied readily formed a hymenium in about a month after isolation of the single spores. Other species would not

¹ KAUFFMAN's maltose agar—to the liter: maltose 5.0 gm., peptone 0.1 gm., magnesium sulphate 0.5 gm., potassium di-hydrogen phosphate 0.25 gm., calcium nitrate 0.1 gm., and agar 15 gm.

fruit readily in culture, and in these instances, fruiting could sometimes be brought about by the following technique. The fungi were grown in glass capsules on filter paper pads, moistened with different nutrient solutions. After sufficient mycelium was formed (10 days or more), the nutrient solution was replaced with sterile distilled water. Fruiting occurred 10-20 days later, depending upon the species.

Sterilized thin slabs of white pine, basswood, and elm were also used in glass capsules with a nutrient solution, or with their respective wood decoctions.

Approximately 600 collections of resupinate Basidiomycetes were made. Many of these were sent to European workers for identification. ABBÉ H. BOURDOT and M. A. DONK both have identified specimens, and have given many helpful comments, this assistance being of great value. In the following discussion, the citation of the author's collection number indicates that a duplicate of that specimen has been deposited in the Herbarium of the University of Michigan.

The following species were studied and cultures were secured from those marked with an asterisk. All the specimens cultured were collected in the vicinity of Ann Arbor, Michigan, with the exception of *Odontia bicolor* from Louisiana.

- * *O. arguta* (Fr.) Quél.
- * *O. fusco-atra* (Fr.) Bres. (three collections)
- * *O. uda* (Fr.) Bres.
- * *O. stenodon* (Pers.) Bres.
- * *O. brinkmanni* Bres.
- * *O. hydroides* (C. & M.) v. Höhn.
- * *O. bicolor* (A. & S.) Bres. (from Louisiana)
- * *O. fragilissima* (B. & C.) Brown
- * *O. separans* (Peck) Brown
- O. himantia* (Schw.) Bres.
- O. fimbriata* Fr.
- O. setigera* (Fr.) Miller

Results

Odontia arguta (figs. 1, 3, 4, 5, 6, 7)

Odontia arguta (Fr.) Quél.,—Fl. Myc. Fr. 435. 1888.

BRESADOLA, Atti. Accad. Rovereto III. 3:98. 1897.

BOURDOT & GALZIN, Hym. de France p. 427.

Fructification effused in patches up to 60 cm. long by 30 cm. wide, usually smaller, soft, arachnoid to tomentose, thin, adnate, cracking on drying, white to colonial buff (MP)² when fresh, darkening slightly when dry; margin indeterminate, pubescent; spines concolorous with the hymenium, tips lighter, granulate to cylindrical subulate, sometimes slightly flattened and connected at base, crowded, 1–3 mm. long, apices penicillate; hyphae thin walled, 2–4 μ in diameter, loose in subiculum, more compact under the hymenium and in axes of the spines, clamp connections present; basidia 10–16 $\times$ 3–5 μ ; spores hyaline, smooth, variable from broadly oval to subglobose, often apiculate, 3–5 (6) $\times$ 3–4.5 μ ; capitate cystidia arising from the basidial layer or from tramal hyphae, present on sides and between the spines, not in subiculum, the cap part 7–9 μ in diameter on a hypha 2.5–3 μ in diameter, cap soluble in alcohol, potassium hydroxide, chloral hydrate with iodine, hot water, and slowly so in potassium carbonate; the second type of cystidia (fig. 1) of two forms present in the subiculum and on the sides and apices of the spines: the first 1–2 μ in diameter, the second 3–5 μ in diameter, constricted near apex to 2 μ in diameter, the apices of both incrustated with calcium oxalate 2.5–3.5 μ in diameter; masses of calcium oxalate or other mineral matter soluble in hydrochloric acid often found in the subiculum.

This is by far the most common species of *Odontia* in the vicinity of Ann Arbor. It is found on the under sides of rotten logs of both deciduous and coniferous trees. In addition to specimens from Michigan, material from Canada, Iowa, New York, Pennsylvania, and

² The technical color names indicated by (MP) are from MAERZ & PAUL (31). Names followed by (R) are from RIDGWAY (38). The writer has used the recent publication of MAERZ & PAUL because RIDGWAY's Color Standards and Nomenclature is out of print. Many of the names used by RIDGWAY are retained by MAERZ & PAUL, who also included in the index a definite reference to most of the RIDGWAY color names.

North Carolina has been studied, which indicates that it has a wide distribution in North America.

One of 15 attempts to culture this species was successful. The basidiospores germinated on agar plates in 3-5 days at room temperature. They produced a single germ tube which became branched within 48 hours. The mycelium was mostly submerged in the agar. On the surface it developed a thin compact film. The color varied from white to cream, and when fruiting, it became cream colored. Spores were produced after a period of 20-30 days. They germinated somewhat readily at the end of 3 days.

This fungus produced spines on nutrient agar (fig. 3), on filter paper pads (fig. 4), and on wood (figs. 5, 7). Nearly typical spines were produced on the under side of the filter paper pads (fig. 4), and branched upright structures were formed on the upper surface of filter paper pads, on agar, and on wood. The capitate cystidia and the oxalate incrustated cystidia, so characteristic of this species in nature, were not produced in culture.

Cultures grown in light or in darkness at room temperature did not show any appreciable variation in the rate of growth or fruiting.

This species is homothallic, as shown by the fact that 22 monosporous cultures produced teeth with hymenium, typical basidia, and basidiospores. Clamp connections were present on all mycelia.

Odontia fusco-atra (figs. 8, 9, 10)

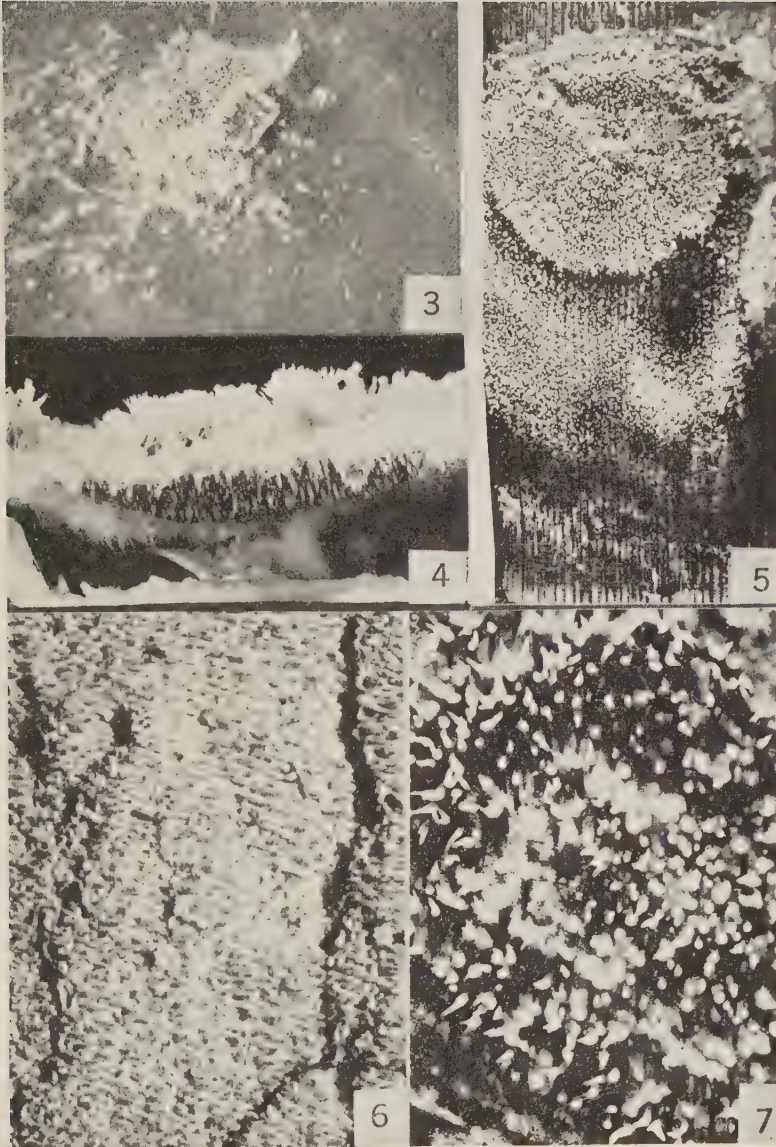
Odontia fusco-atra (Fr.) Bres.,-Atti. Accad. Rovereto III. 3:95. 1897.

Acia fusco-atra (Fr.) Pat.,-BOURDOT & GALZIN, Hym. de France p. 417.

Mycoacia fusco-atra (Fr.) Donk,-Med. Ned. Myc. Ver. 18-20:152. 1931.

Hydnum carbonarium Peck,-N.Y. State Mus. Rept. 40. p. 55. 1887.

Fructification effused in patches up to 60×10-20 cm., thin, adnate, color variable from bluish white to peach beige (MP) to cinnamon brown (MP) to burnt umber (MP) when fresh, art brown (MP) to black when dry; margin bluish white to yellowish, pruinose or finely byssoid; spines slender, subulate, pointed or with apices di-



FIGS. 3-7.—*Odontia arguta*: Fig. 3, culture in petri dish on KOTILA's agar; natural size. Fig. 4, same on filter paper pad showing typical teeth produced on lower surface; $\times 2$. Fig. 5, same on pine wood; natural size. Fig. 6, fruit body (no. 426) on rotten hardwood. Ann Arbor, Mich.; $\times 5$. Fig. 7, culture showing detail of spines; $\times 5$.



FIGS. 8-11.—Fig. 8, fruit body of *O. fusco-atra* (no. 417) side view, on basswood. Collected near Ann Arbor, Mich. Fig. 9, looking down on tips of spines of same fructification. Fig. 10, dried specimen of same showing clumping of spines or “molariform” teeth. Photograph by EDGERTON. Fig. 11, *O. uda* (no. 426) collected near Whitmore Lake, Michigan. $\times 5$.

vided, concolorous with the subiculum or with tips lighter colored; subiculum hyphae moderately dense, becoming more compact just under the hymenium, $2.5-3\ \mu$ in diameter, thin walled, with clamp connections; hyphae in axes of spines compact, parallel, ascending to somewhat interwoven; cystidia incrusting, $5-8\ \mu$ in diameter, abundant in axes of the spines, usually imbedded, sometimes projecting from the spines at various angles; cystidioles occasionally present on the sides of spines, subulate, difficult to detect; basidia $14-20 \times 3-4\ \mu$; spores oblong cylindrical, sometimes slightly curved, $4-5 \times 2\ \mu$.

Twelve collections from the vicinity of Ann Arbor (nos. 417, 425, 81) were studied and also one collection each from New York, Ohio, North Carolina, and Holland respectively. The New York collection (no. 34) was determined by BOURDOT.

The variations noted in the color of this species, when compared with the relative constancy of color in a number of other species of the group, suggested that two or more species might be involved. However, a study of two fresh collections showed a change in color from bluish white to cinnamon brown (MP) in less than an hour. The burnt umber (MP) color appeared in about two hours, and the dried collections varied as noted. Material has been collected in the field in which the specimens were uniformly cinnamon brown (MP) and uniformly burnt umber (MP). Other collections have shown a mottled appearance caused by transitional changes in different areas.

Fourteen monosporous cultures were made successfully from three specimens collected in 1929, 1930, and 1932. Monosporous cultures of these had clamp connections, produced basidia and basidiospores. Repeated isolations behaved likewise, thus establishing the homothallic nature of the fungus. A variation in the time it took monosporous cultures to fruit is worthy of mention. Fruiting usually occurred in 30 days at room temperature on maltose agar and in 20 days on KOTILA's agar. Some cultures, however, required three to four months to mature.

This species produced mostly submerged mycelium with merely a scant floccose film over the surface of the agar. The fructification was a yellowish crust on the surface of the agar and was composed of a compact palisade-like layer of basidia with here and there an up-

right incrustated hypha. These incrustated hyphae or cystidia were similar to those found in the axes of the spines, but differed in having larger granules forming the incrustation, and they usually occurred solitary. The striking color change exhibited by field collections was absent from cultures on agar or on filter paper pads.

An examination of the type of *Hydnum carbonarium* in the Herbarium of the New York State Museum resulted in finding that the specimen is a depauperate or young stage of *Odontia fusco-atra*.

Odontia uda (fig. 11)

Odontia uda (Fr.) Bres.,—Atti Accad. Rovereto III. 3:97. 1897.

Acia uda (Fr.) B. & G.,—Hym. de France p. 414.

Mycoacia uda (Fr.) Donk.,—Med. Ned. Myc. Ver. 18-20:151. 1931.

Fructification effused, in small patches, 3-6×1.5-2 cm., thin, soft, waxy, adherent, sulphine yellow (R) to naphthalene yellow (R) when fresh; margin indeterminate, pruinose, whitish to concolorous; spines concolorous with the hymenium, slender, elongated, 0.5-1 mm. long, solitary or slightly confluent, crowded, apices entire or denticulate; hyphae of the subiculum very compact, 2.5-3 μ in diameter, flexuous, septa few; hyphae of the subhymenium thinner walled, abundantly septate, clamp connections present; hyphae in axes of the spines adherent, very compact, 3-4 μ in diameter; basidia 13-16×4-5 μ , clavate; spores 4-6×2.5-3 μ , hyaline, oblong cylindrical and often containing two shining drops; cystidioles subulate, projecting 6-10 μ beyond the hymenium, 2-3 μ in diameter. After rejuvenation the spines may be densely bristly with hyphae or cystidioles (?) 2-3 μ in diameter.

Nine collections were made in Michigan of which no. 36 was determined by BOURDOT. It occurs on rotten hardwood logs, and is found more frequently on *Fraxinus nigra* than on other hardwoods.

When in good growing condition this fungus has a strong anise odor and exhibits a striking color reaction to alkali (5). Treating sections with potassium hydroxide produces a reddish violet color. Exposure of pieces of a specimen to the fumes of ammonia produces a violet color. BOURDOT and GALZIN (5) have distinguished *Odontia* (*Acia*) *uda* from *O.* (*Acia*) *fusco-atra* by this reaction.

Six monosporous cultures were made of *Odontia uda*. The mycelium produced by the single germinated spores was $2.5\text{--}4\ \mu$ in diameter, septate, and had clamp connections on the septa. Chlamydospores $8\text{--}15\ \mu$ in diameter were abundant in the cultures. The basidia were oblong-clavate, $15\text{--}30 \times 3\text{--}4\ \mu$ in diameter. All six monosporous cultures formed clamp connections, produced basidia and basidiospores, and *Odontia uda* is therefore a homothallic species.

Small penicillate spines were produced on the upper surface of filter paper pads moistened with different nutrient solutions. The spines consisted of clusters of spreading, upright, slightly incrustated hyphae. The lower part of these spines was covered with the hymenium. The cultures produced a very strong, characteristic odor of benzaldehyde rather than the anise odor of fresh specimens. There was no color reaction when the mycelia of the cultures were exposed to the fumes of ammonia as was noted for material collected in the field.

Odontia stenodon

Odontia stenodon (Pers.) Bres.,—Atti. Accad. Rovereto III. 3:96. 1897.

Mycoacia stenodon (Pers.) Donk,—Med. Ned. Myc. Ver. 18:20: 151. 1931.

Acia stenodon (Pers.) B. & G.,—Hym. de France p. 415.

Oxydontia stenodon (Pers.) Miller,—Mycologia 25:294. 1933.

Fructification effused, in patches $10\text{--}15 \times 8\text{--}10\text{ cm.}$, adnate, waxy, cracking when dry, white to yellowish, pale salmon (R) when fresh, drying with yellow and reddish colors; margin fibrillose, radiating, narrow, white; spines often nodose, clustered or crowded, slender, connate at base, 1–3 mm. long; hyphae of subiculum very compact, agglutinated, $2.5\text{--}4\ \mu$ in diameter, moderately thick walled, the structure difficult to distinguish; hyphae in axes of spines compact, agglutinated, $3\text{--}4\ \mu$ in diameter, prolonged into sterile point or sometimes divided, apparently not incrustated, clamp connections present; basidia clavate, $15\text{--}24 \times 3\text{--}5\ \mu$, 2–4 sterigmata $2.5\text{--}3\ \mu$ long; no cystidia; cystidioles $2.5\text{--}3\ \mu$ in diameter on a level with the basidial layer or projecting $2\text{--}5\ \mu$ beyond; spores hyaline, oblong allantoid, $3.5\text{--}5.5 \times 2.5\ \mu$.

Three collections of this fungus were studied; one from New York, no. 35, which was determined by BOURDOT, and two from Michigan.

Both two- and four-spored basidia were found side by side in the hymenium on the same tooth.

A multisporeous culture produced very little aerial mycelium but typical teeth were formed on the agar. Structurally the teeth were identical with those produced in nature. The hyphae of the submerged mycelium ranged from 1.5 to 4 μ in diameter, septate, with clamp connections. Incrusted, aerial hyphae were produced.

Odontia brinkmanni

Odontia brinkmanni Bres.,—Ann. Myc. 1:88. 1903.

Grandinia brinkmanni (Bres.) B. & G.,—Hym. de France no. 321. Bull. Soc. Myc. de France. 1914.

Fructification effused, forming patches 10–20 cm., thin, pruinose, adherent, white when fresh becoming yellowish on drying; margin subindeterminate; spines hemispherical, crowded, often conical and elongated; hyphae of the subiculum moderately loose, 1.5–4.5 μ in diameter, thin walled, often collapsing, clamp connections present; basidia urn-shaped, 4–8 spored with short sterigmata; spores hyaline, smooth, subelliptical, 4–6 $\times$ 2–2.5 μ ; no cystidia; oxalate crystals abundant in the subiculum and spines.

This species was collected twice in Michigan, and one collection (no. 27) was determined by BOURDOT. It occurs on rotten hardwood logs.

In culture it produces a white to cream colored mycelium, at first chiefly submerged, later aerial and floccose. The mycelium of multisporeous origin had clamp connections; however, it never produced basidia and basidiospores. Beadlike chains of thick walled chlamydospores were developed. Single chlamydospores were isolated and the mycelium produced was septate with clamp connections, white, and more floccose from the start than that produced from the basidiospores. However, no fructifications were produced.

Odontia hydnoides (figs. 2, 13)

Odontia hydnoides (Cooke & Massée) v. Höhn.-K. Akad. Wiss. Wien.

Math. Naturw. Kl. Sitzungsber. Vol. 118: Abt. 1. p. 5-6. 1909.

Not *Odontia hydnoides* (Schw.) Peck, -N.Y. State Mus. Bull.

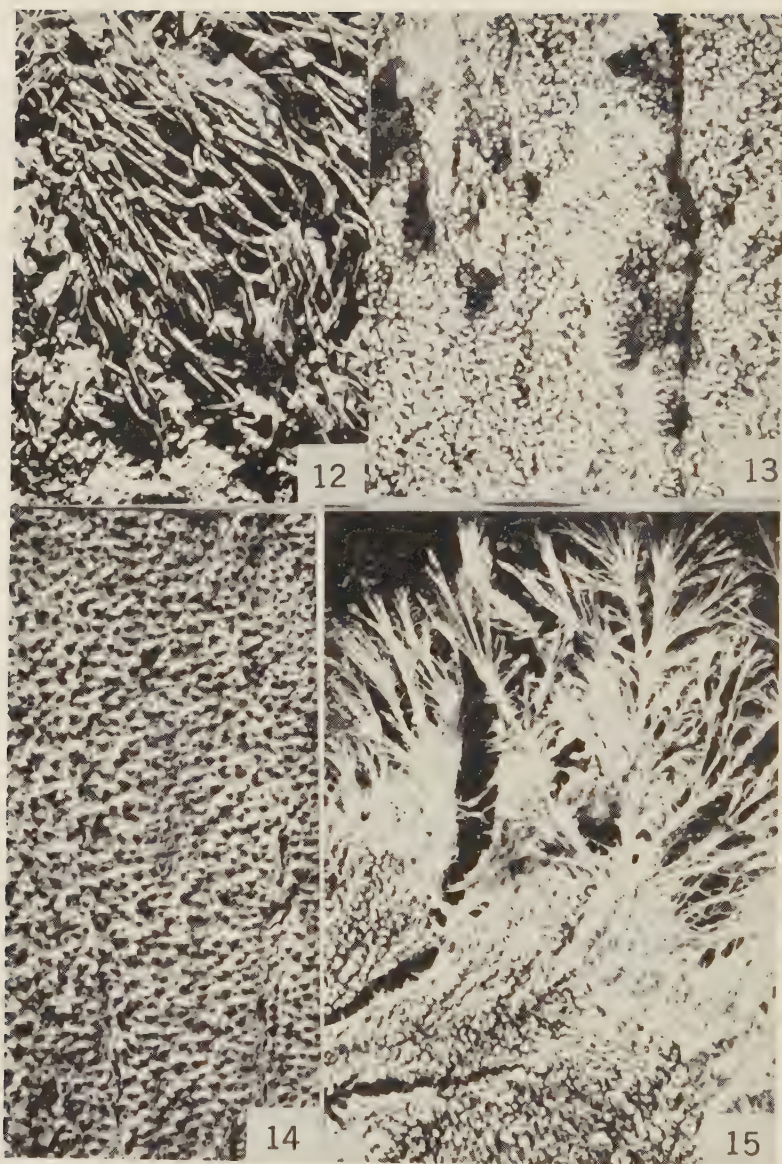
67. 39. 1903.

Fructification effused, in patches up to $40 \times 15-25$ cm., thin, adherent, waxy, crustaceous, pale gull grey (R) to pale smoke grey (R) with wax yellow (R) areas, finally at maturity light buff (R) or chamois (R); margin subdeterminate; spines concolorous varying from mere granules to teeth averaging from 0.5 to 1 mm. in length, subulate, fimbriate, with rigid bristles scattered or in fascicles as seen under the hand lens, fragile, easily rubbed from the subiculum; hyphae of the subiculum compact, agglutinated, indistinct; cystidia abundant, strongly incrustated with oxalate, some with thick walls and narrow lumen, others with thinner walls and larger lumen, conical to fusiform, $53-100 \times 10-21 \mu$, layered in the subiculum, partially imbedded in the spines or projecting at various angles and fascicled at the apices; hyphae in axes of the spines incrustated, septate, cylindrical, $8-12 \mu$ in diameter, extending beyond the apices $20-40 \mu$, thinner walled than the cystidia; basidia $3.5-4 \mu$ in diameter, length not determinable; spores $3-5 \times 1.5-2 \mu$, oblong cylindrical, slightly flattened on one side, hyaline, usually with two guttulae. Incrustation soluble in hydrochloric acid.

The axillary incrustated hyphae have the power of regeneration. These hyphae, which are $10-12 \mu$ in diameter, may from their apices give rise to hyphae $4-5 \mu$ in diameter.

Specimens from England, Germany, France, and Holland were kindly loaned by DONK. A study of these, in comparison with 20 collections from Michigan and one from Louisiana, has convinced the writer that the American material is not specifically distinct from the European plants. The cystidia figured by VON HÖHNEL are very similar to those found in American collections.

In 1907 VON HÖHNEL and LITSCHAUER (21) described this fungus as a new species, *Peniophora crystallina*. In 1908 they (22) decided that this material was a delicate corticium-like variety of *Odontia conspersa* Bres., and reduced it to a variety, *O. conspersa* var. *crystal-*



FIGS. 12-15.—Fig. 12, *O. separans*: dried specimen collected by D. H. BELL, 1914. Fig. 13, *O. hydroides* (no. 523) on rotten hardwood, Whitmore Lake, Mich. Gull grey (R) phase. Fig. 14, *O. bicolor* (no. 30) on coniferous wood, Nelson, N.Y. Determined by BOURDOT. Note darker tips to spines of dried specimen. Photograph by EDGERTON. Fig. 15, *O. fimbriata* (no. 427), Ann Arbor, Mich. Note fimbriate margin and exceedingly small, fimbriate spines. $\times 5$.

lina (v. Höhn. & Litsch.). In 1909 VON HÖHNEL (19) called attention to three prevailing forms of this fungus, the odontia-like, the grandinia-like, and the peniophora-like forms. At the same time he reported on his study of COOKE and MASSEE's original specimen of *Peniophora hydroides* which is an *Odontia*, and therefore created the combination *O. hydroides* (Cke. & Mass.) v. Höhn. That this fungus is decidedly variable can be seen from the treatment given it by different students. Thus VON HÖHNEL (21) and DONK (16) consider it a *Peniophora*, BRINKMAN (in VON HÖHNEL and LITSCHAUER 22) a *Grandinia* BOURDOT & GALZIN (5), and CEJP (13, 14) an *Odontia*. The writer believes that it is an *Odontia* because of the well developed spines present in the mature fungus.

The color of this fungus is variable. Some specimens are gull grey (R) and others are light buff (R) to chamois (R). The gull grey specimens are young forms. The color change from gull grey to whitish or light buff was observed for two collections. Both colors have been noted on the same specimen in several instances. The average American collection shows some minor variation from the European material, in that the teeth are better developed, the cystidia have thicker walls and are stouter. There are gradations in the shape and size of the cystidia between collections of the American and of the European specimens.

The monosporous cultures of this fungus produced a thin, skinlike layer of mycelium over the surface of the agar. Around the margin of the petri dish and on the drier areas of the media in the test-tubes, thick, white, appressed, felty mycelium formed. The submerged hyphae were thin walled, 2-5 μ in diameter, and were slightly incrustated with small granules, becoming agglutinated into bundles but not forming rhizomorphs. Clamp connections were present but rare. Globose chlamydospores were abundant. They were 8-16 μ in diameter, thin walled at first, becoming thick walled in old cultures. They stained very dark brown with iodine solution or chloral hydrate with iodine.

The presence of clamp connections and the fruiting of monosporous cultures demonstrated the homothallic nature of this fungus.

It is slow to fruit in culture, although it is stimulated by a reduction in food supply. When KOTILA's nutrient solution was replaced

by sterile distilled water in 10-day-old cultures on filter paper pads, fructification followed readily in 10–15 days. Check cultures were kept for 49 days with no signs of fruiting. When the nutrient solution was removed from these and replaced by sterile distilled water, basidia and basidiospores were produced in 11 days. The hymenium developed in culture had an irregular, crustlike formation and the typical, incrustated, fusoid cystidia characteristic of the field collections were not produced in culture in any case.

Odontia bicolor (fig. 14)

Odontia bicolor (A. & S.) Bres.,—Ann. Myc. 1:87. 1903.

H. balsameum Peck,—N.Y. State Mus. Bull. 75. p. 15. 1904.

H. serratum Peck,—N.Y. State Mus. Rept. 50. p. 112–113. 1897.

Fructification broadly effused, variable, 8–60×5–20 cm., thin, adnate, subtomentose and pruinose to waxy and pruinose, white when fresh to milk-white (R) to cream color (R) when dry, cracking; margin determinate; spines conical to subulate, short, 0.5–1.5 mm. long, solitary or crowded, apices fimbriate, serrate on sides, on drying often forming fasciculate clusters especially when the teeth are long, apices often rufescent when dry; hyphae of the subiculum compact, interwoven, 1.5–2 μ in diameter, septate with clamp connections; hyphae in the axes of the spines thick walled, 5–8 μ in diameter, often agglutinated and slightly yellowish, extending beyond the apices of the spines 20–50 μ , 3–5 μ in diameter and thinner walled; basidia clavate, 10–20×3–5 μ , 2–4 sterigmata 4–5 μ long; spores oblong ovoid, apiculate, hyaline, smooth, 4–6 (8) ×3–4 μ ; cystidia of two types: one globose, spiny oxalate crystals 8–16 μ in diameter, incrustated on hyphae 1.5–2.5 μ in diameter, occurring on the sides and apices of the spines or in the subiculum near the substratum, incrustations soluble in hydrochloric acid; the other capitate cystidia, incrustations 7–9 μ in diameter on the sides and apices of the spines, cap part soluble in potassium hydroxide, alcohol, and chloral hydrate with iodine.

Specimens from New York, Michigan, Louisiana, Jamaica, and Holland were studied. The New York collection (no. 30) was determined by BOURDOT.

The types of *Hydnum balsameum* and *H. serratum* in the Herbari-

um of the New York State Museum, Albany, New York, show the same spiny crystals and capitate cystidia which are so characteristic of this species.

Not all attempts to get this fungus into culture were successful. Good spore deposits were secured in every case, but the spores would not germinate readily in distilled water or on agar at room temperature ($20^{\circ}\text{C}.$). Twenty germinated single spores were isolated from material collected in Louisiana (no. 342) but only three (nos. 1-3) grew. The growth habit of no. 3 was markedly different from that of nos. 1 and 2, as the mycelial mat formed was from three to four times the size of the others. The mycelium from the no. 3 culture was more superficial, byssoid, and zonate whereas in the other two it was more floccose and azonate. These single spore cultures did not produce any clamp connections on the hyphae after a period of five months. The hyphae were moderately thick walled, $2-3.5\ \mu$ in diameter, uniform in size, with occasional irregular swellings, and were septate. No chlamydospores were formed. The mycelia of these were mated as follows: 1×3 , 1×2 , and 2×3 . Clamp connections were formed in the case of 1×3 . From these results it would seem that this species is heterothallic.

This fungus is exceedingly slow growing in culture and forms a mycelium mat of 3-5 cm. in diameter in a period of three months. Small, hyaline, rod-shaped segments $3-5\times 2-2.5\ \mu$ occurred in the single spore cultures, but when the aerial mycelium of the culture was examined under the 8 mm. lens, hyphae made up of many short segments were found, similar to what BREFELD illustrated as oidia. When water was added to the mount, these segmented hyphae disappeared and short, rodlike segments were abundant.

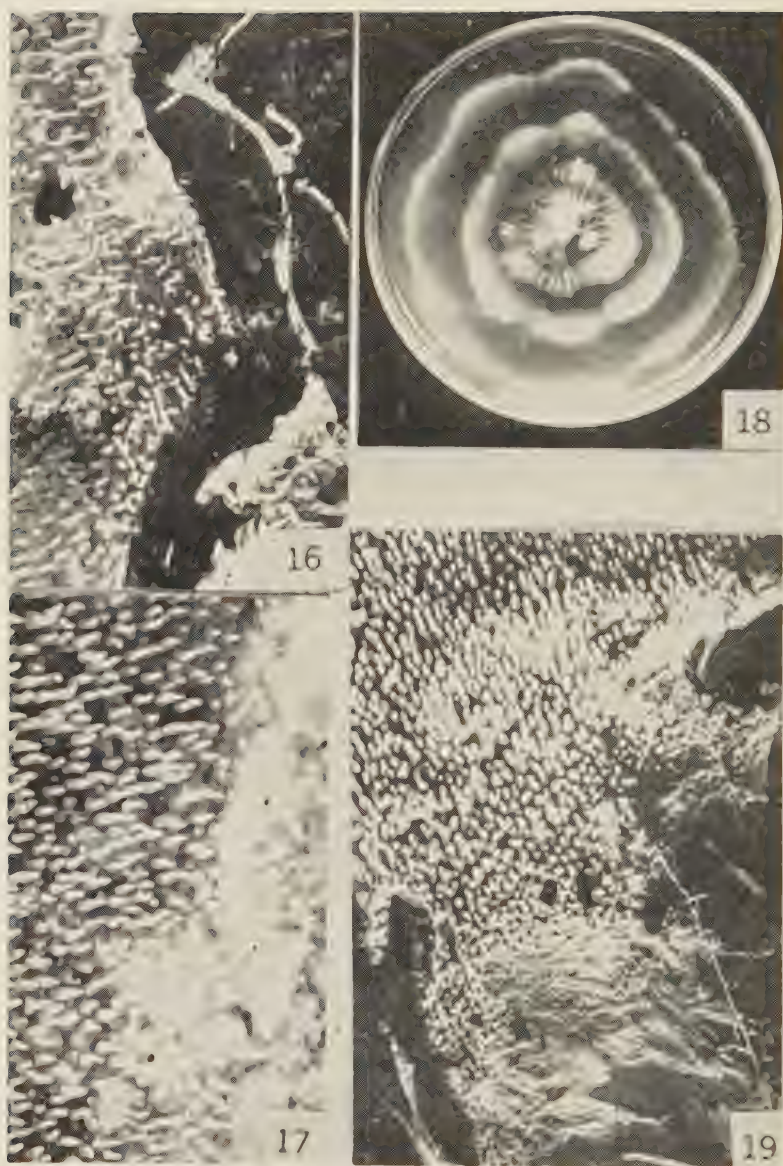
Odontia fragilissima (figs. 18, 19)

Odontia fragilissima (B. & C.) comb. nov.

Hydnum chrysocomum Underw.,—Bull. Torr. Bot. Club **24**:82. 1897.

Oxydontia fragilissima (B. & C.) Miller,—Mycologia **25**:294. 1933.

Fructification effused, 2-6 to $60\times 15\ \text{cm.}$, thin, fleshy-membranaceous when fresh, papery-membranaceous when dry, separable from the substratum, yellow to chrome orange when fresh; margin white,



FIGS. 16-19.—Fig. 16, *O. himantia* showing rhizomorph. Fig. 17, *O. himantia* (no. 545) showing acute and obtuse spines and cottony subiculum. Ann Arbor. Fig. 18, petri dish culture of *O. fragilissima* grown at 25° C. Note concentric zonations. Fig. 19, *O. fragilissima* (no. 429), Ann Arbor, Mich. Note spines and rhizomorphs. $\times 5$.

bysoid, fibrous, usually with orange (R) to chrome orange (R) rhizomorphs; spines subulate, for the most part concolorous with the hymenium, apex usually lighter colored, 1-3 mm. long, some slightly flat and connate at the base, distant to crowded, much slimmer when dry than when fresh; hyphae of the subiculum 6-9 μ in diameter, incrustated with fine, orange colored granules, thick walled, compact, clamp connections present but rare; basidia 14-16 $\times$ 4-5 μ in diameter, 4-spored, very compact, arranged on the sides and between the teeth; spores oblong, hyaline, 3-5 $\times$ 2-2.5 μ ; cystidia, when present, finely incrustated, 3-6 μ in diameter, moderately thick walled and projecting 10-20 μ ; lumps of oxalate present in the axes of the spines; hyphae in axes of the spines agglutinated forming a compact bundle, some with very fine incrustations.

The following collections were studied: the co-type of UNDERWOOD'S species *Hydnum chrysocomum* in the Herbarium of the New York State Museum, also one other collection from New York, three collections from Michigan, three from Louisiana, one from Ohio, and one from North Carolina.

This plant can readily be recognized by its bright chrome-orange color, colored rhizomorphs, and the fragile, papery-membranaceous consistency of the dried specimens.

LLOYD (29) emphatically states that this species is *Sistotrema crocea* Schw., although he was unable to find any specimen of it in SCHWEINITZ' herbarium. It is difficult to see how LLOYD could mistake this well marked plant which is characterized by a thin, fragile, separable subiculum and colored rhizomorphs for a plant which was described as firm, tuberculose, rimose, and adnate.

BANKER (1) used the name *Hericium crocea* (Schw.) for plants which are parasitic on apple trees in North America and in Europe. The apple tree parasite is also known as *Hydnum schiedermayeri* Heuf., *Acia setosa* (Pers.) B. & G., and *Mycoacia setosa* (Pers.) Donk. DONK (16), however, believes that SCHWEINITZ' description does not refer to the apple tree parasite and that BANKER'S use of SCHWEINITZ' name for this fungus is unfortunate.

MILLER (33) placed UNDERWOOD'S name *Hydnum chrysocomum* in the synonymy of *Oxydontia fragilissima* but the writer believes the

plant belongs to the genus *Odontia* and has made the combination *Odontia fragilissima*.

A Louisiana collection (no. 332 from Pride, La.) consisted of a yellow colored specimen growing intermingled with an orange colored specimen on the same log and could not be distinguished from it other than by its color, as the microscopic details, presence of rhizomorphs, and consistency of the fruit bodies were identical. This yellow phase has also been noted by J. N. Couch. With a specimen from Chapel Hill, North Carolina, he sent the following note: "This specimen varies from yellow to red, usually with orange rhizomorphs." In a later collection (no. 429) the chrome-orange fruit body was cut off from the wood and the bare stick placed in a moist chamber. In a few days it was covered with a whitish mycelium which soon became chrome-orange. After three to four weeks the color changed to capucine yellow (R), hence the yellow and orange phases were definitely connected.

A tissue culture from one of the Michigan collections was secured from rhizomorphs. It first produced a white, fibrous, aerial mycelium with hyphae 6-8 μ in diameter which had clamp connections. The mycelium was at first hyaline, then chrome-orange. The color is due in part to the fine granular incrustations which sheathe the hyphae, and in part to color in the protoplasm. The color is partly bleached out of the mycelium by potassium hydroxide, Amann's mounting medium, or chloral hydrate with iodine. The granules are somewhat loosened by these reagents; however, hydrochloric acid does not appear to attack them. Chloral hydrate with iodine stains the hyphae dark brown. Cultures grown in light on agar in flasks at room temperature produced concentric zonations around the point of inoculation, while cultures grown in darkness produced a fibrous aerial mycelium with abundant rhizomorphs. Petri dish cultures kept in the dark at 25°, 25°, and 30° C. produced concentric zonations similar to those formed in light (fig. 18). Here the zonation was broader and consisted of rings of aerial mycelium alternating with the submerged mycelium. All attempts to stimulate this fungus to fruit, such as reducing the food supply, changing the carbohydrate-nitrogen ratio, growing it at different constant temperatures and alternating high and low temperatures, failed.

Sixteen monosporous cultures were secured from no. 429, a Michigan collection. The primary mycelium consisted mostly of submerged hyphae of irregular size with swellings and contortions. About three weeks after isolation, the mycelium produced clamp connections, thus indicating a homothallic condition for this fungus. The secondary mycelium was more regular in diameter than the primary mycelium, and did not have the anastomosing network of branches found in the primary mycelium. The mycelium of the single spore cultures behaved like the mycelial cultures from the rhizomorphs in that after six months neither basidia nor basidiospores were formed.

Odontia separans (fig. 12)

Odontia separans (Peck) comb. nov.

Hydnum separans Peck, —N.Y. State Mus. Rept. 50. p. 112. 1897.

Oxydontia macrodon (Fr.) Miller, —Mycologia 25:294. 1933.

PECK described this species as follows:

Resupinate, white; subiculum membranous, at first pure white, becoming yellowish or cream color with age; aculei subulate, glabrous, crowded, 2–3 lines long, fragile, easily separating from the subiculum and leaving in it alveolar impressions; spores globose, colorless, 0.00016 inch broad.

Much decayed wood of deciduous trees. Adirondack Mountains. July.

After the teeth have been separated from the subiculum, it resembles somewhat a shallow-pored species of *Poria*. By this character, the thinner subiculum and the smaller spores the species may be separated from *H. mucidum*, to which it is allied.

PECK reported the spores as globose, colorless, 0.00016 inch broad (4.06 μ). Examination of the type specimen in the Herbarium of the New York State Museum indicated that the spores are broadly ellipsoid, amyloid, and that two types of gloeocystidia are present. The alveolar impressions which PECK noted are common also on other species of *Odontia* when the teeth break away from the subiculum.

MILLER (33) has placed PECK's name *Hydnum separans* in the synonymy of *Oxydontia macrodon* (Fr.) Miller (*Hydnum macrodon* Fr.). This treatment seems unwarranted because the Friesian de-

scription indicates a plant with almost no subiculum, whereas PECK'S plant has a well developed subiculum. For this reason PECK'S name is retained here.

Fructification effused, at first small, orbicular patches, 2 cm. in diameter, later up to 7×4 cm., soft, membranaceous, separable, white when fresh, colonial buff (MP) to amber yellow (MP) when dry; margin indeterminate; spines up to 6 mm. long, subulate, crowded, fragile, easily separated from the subiculum leaving small pits; subiculum moderately dense, hyphae of two kinds, one moderately thick walled, $2.5-4 \mu$ in diameter, often collapsing, septate and with clamp connections, the other very thick walled, 2μ in diameter, walls so thick and lumen so narrow that they sometimes appear like capillary hyphae; basidia cylindrical to clavate, $16-24 \times 7-10 \mu$; sterigmata $3-5 \mu$ long; spores smooth, hyaline, broadly ellipsoid, amyloid, $3.5-5 \times 3-4 \mu$; gloeocystidia of two types: one fusoid with acute to acuminate apices, the other in the axes of the spines thin walled, flexuous, $125-150 \mu$ long, $7-10 \mu$ wide, staining dark brown by chloral hydrate with iodine and reddish by potassium carbonate with eosin; spores turning blue under the action of iodine.

Two collections besides the type were studied, one from the vicinity of Ann Arbor, Mich., and one from Hemlock Ravine (? New Richmond, Mich.), collected by D. H. BELL, 1914, and in the Herbarium of the University of Michigan (fig. 12). The above description is based on these three collections.

Eight monosporous cultures and one polysporous culture of this species were made. The mycelia of the monosporous cultures did not have clamp connections. The mycelium of the polysporous culture showed clamp connections. Therefore, the fungus is apparently heterothallic. It has not fruited in the two years it has been in culture. The mycelia of the single spore cultures have hyphae of two sizes, one 1.5μ in diameter, thick walled, the other $2.5-3 \mu$ in diameter, thick walled, septate. Thick walled, intercalary chlamydospores are produced on hyphae of monosporous cultures. These vary from ellipsoid, $4-6 \times 2-5 \mu$, to globose up to 8μ in diameter. Some granular oxalate incrustations were produced on the hyphae. No gloeocystidia were produced in culture.

Odontia himantia (figs. 16, 17)

Odontia himantia (Schw.) Bres.,—Ann. Myc. 1:84. 1903.

Hydnum subfuscum Peck, —N.Y. State Mus. Rept. 40. p. 55. 1885.

Fructification effused, size irregular depending upon the substratum, cottony tomentose, thin, at first white, then antique gold (MP) to fuscous when old, separable when fresh, sometimes slightly adherent; margin byssoid, determinate, usually with conspicuous rhizomorphs; spines up to 4–5 mm. long, scattered or gregarious, slender, obtuse or conical (often drying conical), entire, white when fresh to fuscous; hyphae of subiculum 2.5–3.5 μ in diameter, smooth, or minutely roughened, septa and clamp connections present; axillary hyphae mostly thin walled, 2.5–4 μ in diameter, agglutinate; basidia clavate, 2–4 spored, 18–38 $\times$ 5–8 μ in diameter; sterigmata subulate, straight, 6–7 μ long; spores cylindrical, often apiculate, hyaline, smooth, size variable depending upon maturity, 8–12 (14) $\times$ 3–5 μ ; no cystidia.

Common on old, rotten frondose or coniferous wood, especially oak. Mycelium of this species appears in the soil and on débris in mid-summer. Fruiting specimens can be found as early as the middle of August, although the best development is later in the fall.

An examination of the type of *Hydnum subfuscum* Peck confirmed KAUFFMAN'S (25) belief that PECK'S species is the same as *Odontia himantia*. PECK commented on the similarity of *H. subfuscum* to *H. himantia* but believed that the acuteness of the spines in *H. subfuscum* denoted a specific difference. The occurrence of obtuse and acute spines on the same plant has been noted and moreover the obtuse spines often become acute on drying.

BOURDOT and GALZIN (5) have placed this species in the genus *Clavaria* under the section *Ceratella*. However, the hymenium occurs between and continuous with the spines and thus it properly belongs in the Hydnaceae.

Odontia fimbriata (fig. 15)

Odontia fimbriata Fr.,—Genera Hymenomycetum 13. 1836.

Mycoleptodon fimbriatum (Fr.) B. & G.,—Bull. Soc. Myc. France 30:276. 1914.

Gloiodon fimbriatum (Fr.) Donk.,—Ned. Bot. Ver. 1:79. 1930.

Etheiroidon fimbriatum (Fr.) Banker, -Bull. Torr. Bot. Club
29:441. 1902.

Fructification effused, size variable, 8-20×5-10 cm., or in small patches, thin, membranaceous when fresh to papery or slightly coriaceous when dry, separable; nude (MP) to onion-skin pink (MP); margin fimbriate and with conspicuous rhizomorphs; spines small, short, conical, crowded, apices appearing bristly under a handlens; hyphae of the subiculum of two kinds, one moderately thick walled, rarely septate, 2-4 μ in diameter, the other thin walled, 3-5 μ in diameter, septations frequent, clamp connections of the same diameter as the hyphae; basidia cylindrical, clavate, 13-18×2.5-3.5 μ ; spores oblong-ovoid, smooth, hyaline, 3-4×2 μ ; cystidia cylindrical, thick walled, septate, 6-19 μ in diameter, projecting beyond the spines 10-50 μ , heavily incrustated with oxalate, soluble in hydrochloric acid. (Potassium hydroxide aids in distinguishing these better than do other reagents.)

Widely distributed on rotten wood. Specimens from Michigan, Pennsylvania, New York, and Ohio were studied.

BOURDOT and GALZIN (4) transferred this species to the genus *Mycoleptodon* because they consider the plant coriaceous and because it has thick walled hyphae making up the subiculum and cystidia similar to those in *M. ochraceum* (Pers.) B. & G. It is not so coriaceous as *M. ochraceum*, however, nor has it ever been found to be effuso-reflexed or dimidiate as are other species included in *Mycoleptodon*, and therefore should be placed in *Odontia*. There are other species of *Odontia* with thick walled, flexuous hyphae and cystidia similar to those in *O. fimbriata*.

Odontia setigera

Odontia setigera (Fr.) Miller, -Mycologia 26:19. 1934.

Kneiffia setigera Fr., -Genera Hymenomycetum 17. 1836.

Kneiffia setigera Fr. Bresadola, -Ann. Myc. 1:103. 1903.

Odontia vesiculosa Povah non Burt., -ПОВАН, Papers Mich. Acad. Sci., Arts, Letters 9:262. 1929.

Fructification effused, in small patches 1-2 cm. on a side, coalescing to form areas 15-30×8-20 cm., separable when fresh and slightly so when dry, very much cracked when dry, whitish when

fresh, agate grey (MP) to ivory (MP) when dry, finally becoming buff (MP) in the herbarium; margin arachnoid, pubescent, subdeterminate to determinate; spines variable, hemispherical to obtuse or cylindrical, less than 0.5 mm. long; hyphae of the subiculum loosely interwoven next to the substratum, thin walled, 3–5 μ in diameter; basidia 16–24 $\times$ 4–6 μ ; sterigmata 4–6 μ long; spores oblong-cylindrical, hyaline, 6–12 $\times$ 3–4 μ ; cystidia imbedded in the axes of the spines and projecting 30–80 μ , 6–10 μ in diameter; irregular, incrustated with oxalate crystals; cystidia, under the handlens appearing as shining “setae,” thin walled, septate, clamp connections on the septa revealed after the incrustation has been dissolved in hydrochloric acid.

On rotten wood, Michigan, Iowa, New York, Louisiana.

BURT gave several herbarium names to this fungus, one of which was *Odontia vesiculosa* based upon a collection by A. H. POVAH from Vermilion, Michigan. POVAH (37) published the name “*Odontia vesiculosa* Burt, ined.,” and gave the host and spore measurements. An examination of his collection in the Herbarium of the University of Michigan has shown that it is *Odontia setigera*.

Discussion

One of the outstanding results of this study is the discovery that a majority of the species are homothallic. BLAKESLEE (2) first reported the occurrence of heterothallism in fungi among the Phycomycetes. Later this phenomenon was found in the Ascomycetes and Basidiomycetes. In the latter, heterothallic forms have been demonstrated among the Uredinales, the Ustilaginales, and the Agaricales. Only a few species of the Basidiomycetes which have been investigated have been homothallic. GÄUMAN and DODGE (18), in discussing sexuality of the Basidiomycetes, state “true homothallism is rare” although “it has been experimentally demonstrated” in certain agarics.

Odontia fusco-atra, *O. stenodon*, *O. uda*, *O. arguta*, *O. hydroides*, and *O. fragilissima* all proved to be homothallic. Strains from single basidiospores produced cultures which had clamp connections on the mycelium and these cultures formed basidia and basidiospores. *O. bicolor* and *O. separans* apparently are heterothallic species. Strains from single basidiospores remained sterile, and the mycelia,

when mated in certain combinations, produced clamp connections. A sufficient number of monosporous cultures were not obtained to justify conclusions covering sexuality.

As was previously mentioned, microconidia, macroconidia, chlamydospores, bulbils, and oidia have been reported by various investigators of these fungi. In cultures of the homothallic species, no bulbils, microconidia, macroconidia, nor oidia were observed. Chlamydospores were present in cultures of both homothallic and heterothallic species. *Odontia bicolor* produced oidia on the mycelium derived from a single spore. Examinations of European and American collections of *Hydnum erinaceus* Bull. and *H. coralloides* (Scop.) Fr. failed to show the macroconidia or microconidia reported by DE SEYNES or by PATOULLARD. The grapelike clusters of spores which they interpreted as conidia were seen, but when potassium hydroxide was added to the mount, the spores separated and a bare hypha was revealed, around which the spores were clustered, and this could not be interpreted as a conidiophore. When iodine was added, these spores turned blue, as did the spores attached to the basidia. The walls of the basidiospores of these species are viscid, as shown by the pronounced adherence of the spores to each other and to the hymenium. It seems probable that the microconidia and macroconidia which DE SEYNES and PATOULLARD described are in reality basidiospores adhering in clusters.

The artificial environment of these fungi in pure culture on different types of media had a marked effect upon the fructification produced. Only two species produced fructifications similar to those formed in nature; namely, *Odontia arguta* and *O. stenodon*. These produced typical spines on nutrient agar, on filter paper pads in nutrient solution, and on woods wet with different nutrient solutions. All of the other species which fruited in culture produced granular crustlike fructifications with no regularity. Thus one of the diagnostic characters of the genus *Odontia*, the presence of a hymenium upon spines, may be decidedly modified or eliminated in artificial culture.

The external appearance of the fructification of *Odontia arguta* in culture was similar to that in nature. However, no characteristic cystidia were developed in culture. The formation of cystidia could

not be induced in cultures of different ages by varying the conditions of heat, light, moisture, and substratum. This lack of cystidia was noted in all cultures, with the exception perhaps of *O. fusco-atra*. This fungus produced scattered, individual, incrusting hyphae (or cystidia?) which projected beyond the hymenial layer. There was no tendency to form a spine around these hyphae, as occurs in nature.

The mycelium of *Odontia uda* in culture did not turn violet color when exposed to the fumes of ammonia as did field collections, and the anise odor of fresh field collections could not be detected in the cultures.

The classification of the resupinate species of the Hydnaceae has undergone various changes with the emphasis that different investigators have placed on the diagnostic characters such as consistency of the fructification, presence or absence of cystidia or other sterile organs, character of the spines, and color of the spores.

The consistency characters of the fructification such as fleshy, waxy, membranaceous, crustaceous, and coriaceous are rather difficult to interpret in these fungi. In fact several students, in describing the same species, have ascribed different consistencies to it. The use of consistency characters for delimiting genera seems to be of doubtful value.

The presence of cystidia is used extensively as a diagnostic character in the classification of fungi. In the Agaricaceae and the Polyporaceae, however, the occurrence of cystidia is not considered of sufficient value to separate genera. BURT (8), in his work with the Thelephoraceae, used the presence of cystidia to separate *Peniophora* from *Corticium*, but did not consider the presence of gloecystidia a generic character. An example of the artificial classification which has resulted from the use of the occurrence of cystidia to separate genera is afforded by the genera *Mycoleptodon* and *Pleurodon*. BOURDOT and GALZIN (4, 5) used the presence of cystidia as one of the characters in *Mycoleptodon* to separate it from *Pleurodon*. In 1932 BOURDOT (3) directed attention to the fact that cystidia occur in one species of *Pleurodon* and are absent in several species of *Mycoleptodon*. He therefore united these two genera. Also the distribution of cystidia in a specimen is often variable, occurring in some portions

and not in others. The use of such a variable character to delimit genera results in an artificial classification and tends to separate closely related species.

The aculei vary from mere hemispherical granules to large subulate spines. They are scattered or gregarious on the subiculum, and often slightly confluent at their bases, especially where the spines are crowded or where the fructification grew on the side of a log. The apices of the spines may be obtuse to acute, or fimbriate or dentate. Drying of specimens causes a distortion of the spines and often a fasciculate clumping. The tendency has been to use the clumping of the spines, their coalescence, and the types of the apices as generic characters. For example, *Odontia* has been characterized by fimbriate or penicillate apices to the spines and *Acia* by entire tips to the spines. However, rejuvenation of the hyphae in the spine following a period unfavorable for growth will cause a fimbriate appearance to an otherwise entire spine. The size and character of the spines vary with the age of the specimen. The fasciculate clumping or molariform type of tooth results from drying in most instances.

The echinulate spore has also been used to delimit genera. In this group, however, there are only a few species with hyaline echinulate spores, and in most instances the markings are not readily visible. The use of this character for generic distinction in the Hydnaceae would result in the establishment of new genera with the same morphological characters as the existing genera, with the exception of the spore marking.

The amyloid condition of the spore has also been used as a generic separation. It also separates otherwise closely related species.

The classification of BOURDOT and GALZIN (5) was chosen as the best treatment to follow when these studies were started in 1929. However, the results obtained did not justify following this classification completely. They recognize four genera of the "Hydnés" as being always resupinate: *Radulum*, *Grandinia*, *Acia*, and *Odontia*. As has been indicated, these genera are differentiated by characteristics that separate closely related species. DONK (16) also considers that these genera are artificial and should be combined. As a result of these studies, the following emendation of the genus *Odontia* is proposed:

Odontia Fr., emended.

Synonyms: *Mycoacia* Donk; *Acia* Karst.; *Grandinia* Fr.; *Gausapia* Fr. pro parte; *Radulum* Fr. pro parte; *Kneiffia* Fr. pro parte; *Oxydontia* Miller.

Receptacle resupinate; consistency varied, membranaceous, crustaceous, waxy, arachnoid, soft or floccose; covered with granules, persistent, hemispherical, or with spines, conical or irregular, apices entire or penicillate; cystidia, gloecystidia, and cystidioles present or absent, incrustated or naked; basidia 2-4-6-8 spored; spores hyaline, smooth or minutely echinulate, amyloid or non-amyloid. The type species is *Odontia fimbriata* Fr.

The type of the genus *Radulum*, *Radulum aterrinum* Fr., is an Ascomycete belonging to the genus *Eutypa* according to VON HÖHNEL (20). Many of the species since placed in the genus *Radulum* are typical odontias.

The type of the genus *Kneiffia*, *Kneiffia setigera* Fr., has been placed in the Thelephoraceae and in the Hydnaceae by different authorities, but is, in its best stage of development, a true odontia according to MILLER (34), who has transferred it to this genus.

The genus *Grandinia* Fr. is usually characterized by the hemispherical granules and by the absence of cystidia. As heretofore indicated, the shape and size of the spines and the absence of cystidia are characters too variable to be used for generic delimitation. Those who recognize the genus *Grandinia* admit that its separation from *Odontia* is artificial. The name *Grandinia* is antedated by *Gausapia* Fr., which, from its use in the Genera Hymenomycetum, should be the valid name if the segregation were maintained.

The genus *Acia* Karst. is usually separated from *Odontia* by the waxy consistency of the fructification and by the entire apices to the spines. Such a separation is artificial. Many of the species recognized in *Odontia* are described as waxy. The entire tip to the spine is very variable, even in the same fructification.

The name *Acia* is also not valid, as it has been used previously for a genus of the Rosaceae. DONK (16) proposed the name *Mycoacia* as a substitute for the invalid name *Acia*. Recently MILLER (32) proposed a new genus *Oxydontia* with the type *O. setosa* (Pers.) Miller.

The generic description, together with the species included in the genus, indicates that instead of a new genus a new name has been proposed for the non-valid name *Acia*.

Summary

1. In studying species of *Odontia*, the use of reagents such as chloral hydrate with iodine and potassium carbonate with eosin has aided in distinguishing structures like cystidia, gloecystidia, and subhymenial hyphae. The differential action of these reagents on spores, gloecystidia, cystidia, and other hymenial elements offers supplementary characters for the identification of species. Likewise a knowledge of the corrosive action of these reagents on these structures is important. It has been shown that variations in descriptions of different investigators can in some cases be traced to the difference in the reagents used in the study of specimens.

2. The necessity for revising the generic concept is shown by this study, and an emended description of the genus *Odontia* Fr. is given. This genus is emended so as to include the species formerly included in the genera *Mycoacia* (*Acia*, *Oxydontia*), *Grandinia*, *Radulum*, and *Kneiffia*.

3. Two new combinations are made, *Hydnum fragilissimum* B. & C. and *H. separans* Peck being transferred to the genus *Odontia*.

4. A study of PECK's types revealed that *Hydnum carbonarium* is the same as *Odontia fusco-atra*; *Hydnum serratum* and *H. balsameum* are the same as *O. bicolor*.

5. The following species were grown in pure culture for the first time: *O. fusco-atra*, *O. uda*, *O. bicolor*, *O. arguta*, *O. separans*, *O. fragilissima*, *O. hydroides*, *O. stenodon*, and *O. brinkmanni*.

6. The following species produced basidia and basidiospores in culture: *O. fusco-atra*, *O. uda*, *O. arguta*, *O. hydroides*, and *O. stenodon*.

7. Only two species, *O. arguta* and *O. stenodon*, produced fructifications similar to those produced in nature. Cystidia, an important diagnostic character, were not formed in culture.

8. The following seven species proved to be homothallic, mycelium from single spores developing clamp connections and producing

basidiospores: *O. fusco-atra*, *O. uda*, *O. arguta*, *O. fragilissima*, *O. hydnoides*, and *O. stenodon*.

9. *O. bicolor* and *O. separans* proved to be heterothallic, the mycelium from monosporous cultures lacking clamp connections which were formed only when two compatible strains were mated.

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